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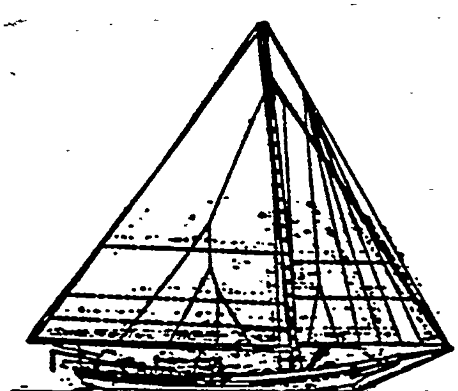

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Technology Assessment in Ship Production

No. 6A

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Abstract

This paper describes a research approach which addresses the format of general systems theory to examine technologies and processes which have the potential for being implemented in the shipbuilding industry. It seeks to create a systematic and logical procedure in which to examine technologies and institutional policies utilized in various other industries and has the potential for creating a strategy for technology and economic impact identification and policy evaluation.\, Decisions as to technologies are currently based on the readily available costs estimated to implement an alternative designed exclusively for the shipbuilding industry. The generation of extensive competing alternatives and innovations is often impossible to perform due to the lack of a comprehensive data source. Secondary institutional and economic impacts are often ignored. A technology assessment algorithm can develop a framework for an assessment revolving around a contingency hypothesis. The approach incorporates a cost analysis of primary economic benefits and disbenefits that will identify affected institutional parties and unanticipated impacts in as broad and long-range a fashion as available data will permit. Resulting recommendations can provide indispensable prerequisites for the definition of alternatives as to their technological, economic, social, and productivity impacts.

The shipbuilding industry in the United States has lost its world prominence in an atmosphere of sluggish demand, static ship prices, inefficiency and over competition. The desire to make the remaining shipbuilding facilities and products competitive with those abroad has brought about the current trends toward increased sophistication of ships, and improvements in energy savings and reliability. An emphasis on cost reductions and the incorporation of technological developments in electronics, factory modernization and automation and communications such as CAD/CAM, FMS, industrial robots, and CIMS may be necessary to the future of the industry. The decisions as to when and where technologies such as these are to be implemented in response to the gradual obsolescence of existing technologies are aided by the process of technology assessment.

Technology assessment involves the examination of alternative technology and then evaluation of them in terms of the goals of the industry and the predicted side effects produced by the change. It is a systematic planning and forecasting process to maximize the benefits of technologies while controlling any potentially harmful or unavoidable secondary economic, environmental, or social impacts. Primary economic advantages and disadvantages can be determined by a benefit-cost analysis with the emphasis on impending issues rather than the current problems requiring corrective action. Technology imported from another company, industry, or country may fail to have the desired effect if it is not accompanied by the proper support systems. An environment that provides an understanding of the capabilities and limitation of the technology, the appropriate resources (machinery, skilled and unskilled labor, management, materials, energy), and effective operating decisions is most likely to promote the assimilation of new technologies.

This paper describes a methodology within the general systems approach to examine technologies which have the potential for being implemented in the shipbuilding in-

dustry. The manner in which a problem situation in the shipbuilding industry is defined at the outset directs all future analysis. If any phase of this initial activity is incomplete, the analysis will not proceed toward a best solution and may not even consider the full set of technology options available to the decision makers. Decisions dealing with the allocation of scarce resources to competing demands or the development of optimal strategies involving choices among a wide range of technology alternatives are best dealt with within the framework of the general systems approach. General systems theory isolates the issue requiring attention from a set of perceived disequilibriums and translates the problem into an analytical framework which can utilize techniques such as cost-benefit studies, contingency analysis, and decision methods. This series of steps will determine the key elements required to analyze the problem and its environment, as well as potential solutions and their repercussions. Figure 1 illustrates a functional flow chart for a technical systems study. The flow of decisions, calculations, and suboptimizations is shown' by tracing the arrows and is broken into three main categories. The first category of steps involves those that conceptually formulate the problem and includes boxes 1 through 4. Boxes 5 through 8 assess and rate the alternatives and optimize the choice of a combination of options. Finally, implementation strategies are developed as shown in boxes 9 through 11. At several points in the progression of decisions and analysis, the designs may be modified and a reiteration, through a portion of process performed. Technology assessment is a major component of the evaluation process depicted in boxes 5 through 7, and the concern of this paper.

The first step in generating technology alternatives for evaluation involves determining the existence of new technologies. The development of new techniques or modifications of those used in the shipbuilding industry or in other industries may be indicated after a thorough search of the literature and national technology sources. Government-* sponsored research and development programs such as the National Shipbuilding Research Program, intra-industry professional societies (SNAME, ASNE), and inter-industry professional societies (ASME, IEEE, IIIE, ASHRE) provides a forum for the sharing of experiences and needs. New technology can also be purchased from other companies and hardware manufacturers, in some instances, or developed by a consultant.

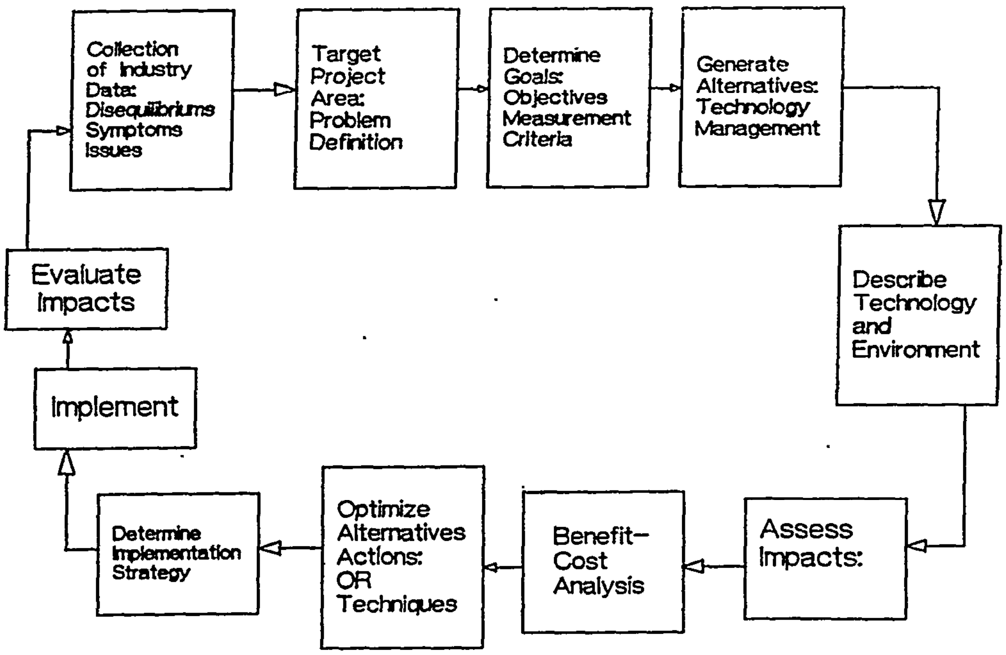

Figure 1. Technological System Functional Flow Diagram

With the generation of various alternatives, it is important to consider that each technology is associated with a set of characteristics that must be fully understood. for example, a particular technique may only be efficient when used in conjunction with sophisticated management techniques, computerized materials handling, or it may make specific demands of energy, transport, or water. When a technology is adapted from another industry it is necessary to recognize that it reflects the circumstances of the economy in which it was developed and is characterized by infrastructure, labor and administration of a particular design and quality. The evaluation of new technology requires a description of potential costs, benefits, personnel requirements, and other variables associated with it in order to be able to later accurately assess its economic, social, and environmental impacts. These items are detailed further in Figure 2.

NEW TECHNOLOGY DESCRIPTION

costs
- hardware/machinery
- implementation
- personnel training
- maintenance
- material requirements
- additional input requirements (water, energy, transport)
- relative factor endowments
- relative factor prices
- information requirements

Benefits
- Improved productivity
- improved safety
- social impacts/job satisfaction
- quality
- reliability
- flexibility

Personnel Requirements
- skills required
- work for size
- utilization of available skills
- personnel displacement
- ability of employees to comprehend and adapt
- employment security
- workforce payment (hourly/salaried)
- worker training requirements
- wage rates

Figure 2

In addition to a description of the new technology, the environment characterizing the shipbuilding industry and the individual plant within which improvements are to be made must be scrutinized fully before any implementation is considered. Figure 3 depicts some of the concerns to be addressed at this stage.

ENVIRONMENTAL CONSIDERATIONS FOR TECHNOLOGY TRANSFER

Economic Circumstances
- price and availability of inputs
- access to inputs
- access to labor of different types
- factors holding up wages (government regulations, trade union activities)
- trends in employment structure/philosophy (higher education levels, less physical labor, shorter work week, flex time)
- position relative to other industries (wage levels, R&D expenditures)

Market Competition
- specialty niche (ship repair, push boat construction)
- market served (local, global)
- market saturation
- market growth
- import/export restrictions (exchange rate, Jones Act)
- status of competition (foreign subsidized)

Infrastructure
- supplier competition
- control over suppliers/degree of vertical integration
- subcontractors
- transport and communications available
- organization of labor market
- basic industry support (domestic steel prices versus foreign)
- scale of operations (may be only one technology efficient at each scale)
- state of available managerial/technical knowledge

Management System Interface
- nature of decision-maker and objectives
  - maximization of profits after tax
  - maximization of local profits before tax
  - employment maximization
  - spread to opportunities to rural areas
  - commitment to change
  - perceptions of various parties about future of the product
- ability of management system to control technology
- changes required in management structure

philosophy regarding motivation, incentives

Hardware Interface
- compliance with present standards
- compatibility with infrastructure

Economic Assistance
- Government
  - national industrial policy
  - tax structure
  - subsidies
  - research and information (NAVSEA 90M, Institute for Research and Engineering for Automation and Productivity in Shipbuilding, National Shipbuilding Research Program)
- Private investment (banks, venture capital, stock market, customers)

Legal System
- intellectual capital
- restrictions on trade (relaxation of Jones Act to allow foreign built hulls on US flag ships)

World Trade
- total volume
- cargo movements
- activities of competitors abroad
- patterns of demand

Figure 3

Once the alternative technologies and the environment in which they are to operate are defined, the technology assessment can proceed through a series of steps designed to analyze the technology, determine its secondary impacts and consider its implementation, possibly with modifications. Beyond the economic feasibility of a new technology, it must also be socially and environmentally acceptable in order to be adopted. Careful attention must be given to the impact of technology on the environment and its use of natural resources. The possibility of air and water pollution resulting from new technologies are often examined environmental impacts. Employment level stability and industry dominance of the local economy are examples of important social impacts. The results of a thorough technology impact assessment can add much insight into project evaluation with the results of the assessment creating the background for the cost/benefit analysis

The arrow diagram is a valuable analysis technique for defining a system through the interrelationships of its major component elements. Arrows connect each pair of parameters that have a cause-effect relationship. When a change in one variable causes a change in a second variable in the same direction, it is defined as a positive relationship and denoted by a plus sign. If that effect is in the opposite direction, it is defined as a negative relationship and denoted by a negative sign. Figure 4 illustrates an example of an arrow diagram describing the dynamics of shipyard considering optimization of the location of its toolsheds. Through this diagram, the first and second-order expected impacts of the technology can be recorded. The total- set of arrows comprising the model illustrate the economic, social and environmental impacts upon the shipyard that will result from modifications to combinations of elements.

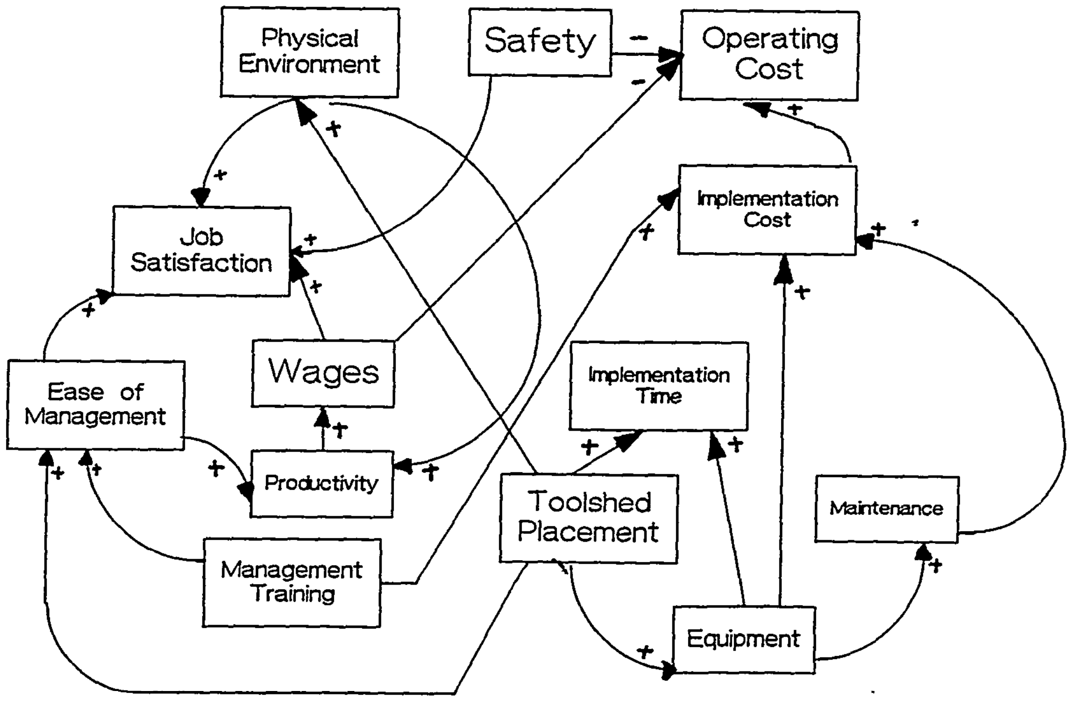

Figure 4. Arrow Diagram of Tool Shed Optimization

New technologies often require a rethinking of production procedures, materials, design, and the management system. These changes are frequently inconsistent with standard operating procedures and it must he assumed that some of the changes required to implement new technologies will add sufficient cost to make the total cost of the new technology unacceptable. Some of the new and modified technologies in the shipbuilding industry are depicted in Figure 5. The relative desirability of technology alternatives is finally to be assessed with a benefit-cost analysis. This analysis essentially calculates the ratio of excess benefits over costs by dividing the project benefits by the projects costs, with an incremental analysis performed whenever more than two alternatives are being compared.

Because of the absence of a comprehensive data source on alternative technologies for application in the shipbuilding industry,* and because technologies from their industries often undergo forced implementation, it is especially important that a systematic framework for the evaluation of new technologies be adopted. The methodology described here for a thorough technology assessment can assist in the complicated task of evaluating the technological alternatives and the future consequences of their implementation.

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TECHNOLOGY FORMAT CHANGES IN THE SHIPBUILDING INDUSTRY

	Traditional Shipbuilding	New Technologies
Production	System oriented electrical, hull	Process oriented cutting, welding, outfit
	lay keel, build up multiple ship runs	build by zone - unit, block, ship
Capital Equipment	Docks, ways	Welding lines, robots, cranes, paint shed
Lead Time	Long each run unique	Short - standardized modules
Inventory	Stored	Just-in-time
Working Plans	Blueprints	Formalized work packages, data-base intensive
Flexibility	Through floor level changes	Through feedback, module modification

Figure 5

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